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EDITORIAL

CONTRIBUTIONS FROM ALLIED SCIENCES TO GEOLOGIC FUNDAMENTALS

Probably there never was a time in the history of our science when contributions from related lines of inquiry were more frequent or more vital than now. Certain it is that the related lines of inquiry were never before so numerous or so searching. Some of the results recently reached in geophysics, geodynamics, radioactivity, micro-seismology, geodesy, and other lines are singularly instructive. While it is scarcely possible for the working geologist, pressed to the limit by his own urgent inquiries, to keep a close watch on the procession of papers that pour forth from all the sciences that bear on his own, there is none the less need to follow as fast as may be in the wake of progress in related sciences.

Formal reviews and synoptical notices are indeed a great aid to this but as a rule these are prepared by those interested in the science to which the papers primarily relate, and for those so interested, and the bearings of these papers on geologic problems are rarely noted even if the author has dropped suggestions in this line. This need and this infelicity in the usual means of meeting it have given birth to the thought that it might be helpful if those geologists who have occasion to read in related sciences were to call the attention of their fellow-workers to points of special interest or value as they may find them, particularly if these points are such as seem likely to escape due appreciation. Of course if the new light comes with a dazzling flash, as did the Röntgen rays and the radioactive emanations it may be assumed that its own penetrating power will suffice, or if it comes in the disturbing fashion of seismic tremors these may be trusted to shake us up duly; but there are sources of light of a much gentler type that throw scarcely less luminosity on some of our dark problems. A note or a hint as these are met may serve busy fellow-workers a good turn. We venture at least to give the thought a trial.

If anyone feels that our science is losing something of its fear-some interest by the decadence of faith in the nether lake of fire, he may find some slight consolation by turning to the growing list of titles of this disturbing sort: "The Gravitational Instability of the Earth,"¹ "The Problem of Gravitational Instability,"² "On the Vibrations and Stability of a Gravitative Planet,"³ and "On the Dilatational Stability of the Earth."⁴ These themes open up quite a new line of inquiry relative to the central balancing of the earth. They imply the possibility that a symmetrical unstable centering of the earth's gravity is liable to pass into unsymmetrical stability. There is thus brought into consideration a possible diastrophism of a profound type. We take kindly to this for it seems a fresh line of support to the view that diastrophism may be as deep as the earth itself, a view that grows up naturally along with the thought of a growing earth with growing stresses at all stages. This view of gravitational instability may not be equally welcome to those who assign the earth a heart of gas, for if the central balance is ever unstable and becomes disturbed, the unbalanced stresses are favorable to the escape of the gas from its state of enormous compression and the stresses are withal well suited to aid in opening the way of escape.

If we feel forced to believe that the heart of the earth is less fluidal than we once thought, there is now the alternative of feeling quite sure that it is compressible. So long as we were taught that the atom was an ultimate thing, impenetrably hard and indivisibly coherent, there was ground to feel that when a planet became compressed in its central parts so that the atoms touched one another, compression could go no farther; but now that the approved picture of the atom is that of minute corpuscles revolving in orbits at prodigious velocities, some of them now and then flying the track and disclosing their small sizes and great speeds, the view of incompressibility loses all rational basis. Compressibility of

¹ A. E. H. Love, *Phil. Trans. Roy. Soc. London*, A, CCVII (1907), 171.

² A. E. H. Love, *Some Problems of Geodynamics*, University Press, Cambridge, England, 1911.

³ J. H. Jeans, *Phil. Trans. Roy. Soc. London*, A, CCVII (1903), 157.

⁴ Lord Rayleigh, *Proc. Roy. Soc. London*, A, LXXVII (1906).

the *atoms*, as well as reduction of interatomic space, is now definitely recognized as a possibility and even a probability by Richards¹ and others. The diastrophism of the atom is now to be a theme of inquiry, as well as the diastrophism of the earth.

Most of the old computations of geophysical application were based on assumed incompressibility, but mathematicians and geophysicists are already reworking their computations on the basis of compressibility. This finds expression in such recent titles as "General Theory of a Gravitative Compressible Planet," "Effect of Compressibility on Earth Tides," "Vibrations of a Gravitative Compressible Planet."²

It tallies well with the new ideas of compressibility that there should be coming to light new forms of familiar substances as these are forced to pass through changes of physical condition, particularly changes of pressure. Bridgman, in a group of notable papers,³ recognizes *five solid forms of water*, and hints that there may be more. In this series of contributions there seems to us to be ground for the inference that molecular rearrangement may not improbably be a common rather than an exceptional property when conditions of pressure notably change. It is perhaps not too much to surmise that a *succession* of rearrangements of molecules may take place where there is a succession of marked changes of pressure, such, for instance, as would arise with increasing depth in the course of the earth's growth, assuming that it grew by solid accretions. Some few such rearrangements falling within the limits of the solid state are well known, but it now seems not unlikely that there may be a series of such rearrangements following the analogy of the five solid states of water treated by Bridgman.

¹ Theodore W. Richards, *Year Book No. 11*, Carnegie Inst. of Washington, 1912, p. 255.

² A. E. H. Love, *Some Problems of Geodynamics*, University Press, Cambridge, England, 1911.

³ P. L. Bridgman, *Contributions from the Jefferson Physical Laboratory of Harvard University*, IX (1911), Nos. 4, 5, and 6; "The Measurement of Hydrostatic Pressures up to 20,000 Kilograms per Square Centimeter," *Proc. Am. Acad.*, XLVII, No. 11; "Mercury, Liquid and Solid, under Pressure," *Proc. Am. Acad.*, XLVII, No. 12; "The Collapse of Thick Cylinders under High Hydrostatic Pressure," *Phys. Review*, XXXIV, No. 1; "Water, in the Liquid and Five Solid Forms, under Pressure," *Proc. Am. Acad.*, XLVII, No. 13.

These contributions and the following one also strengthen the view that transitions of form take place by fractional action, portions passing to the fluid state and back again in succession while the larger portion at any one instant remains solid. It is of course well known that some geologists regard the deformations and movements of ice and of other crystalline rocks as a process of this kind, though more commonly assigned to viscous or plastic properties.

In the interest of sharper analytical discriminations, Johnson and Adams¹ have drawn clear lines of distinction between different *kinds* of pressure and their diverse effects. Their welcome paper clarifies a field over which fog has hung rather thickly. This clear demarkation of distinctions will no doubt help relieve "plasticity" of an overburden of service as the putative creature of hydrostatic pressure. It will then be free to come into proper service occasionally as *unbalanced* stress invokes it. Let us hope that the notion that *free and easy* movement goes with "pressure plasticity" may be honored with a place on the historic shelf, and that a place beside it may be reserved for its close cousin, the notion that "flow" of rocks under differential pressure carries the quality of facile fluency.

It is prudent to note, however, that new light is often only partial light, sometimes merely a dim dawning that may lead astray rather than make clear the true way. Some of the determinations of Tammann,² important as they are in themselves, were so interpreted at first as to seem to some geologists to lead back to the old view of fluidity wherever in the heart of the earth pressure is great, but the still more extended experiments of Bridgman with their acutely critical interpretations point to solidity and rigidity,³ as do so many other lines of recent inquiry.

Most of these other lines are familiar, but the full significance of the determination of the body tide of the earth by Hecker⁴

¹ John Johnson and L. H. Adams, "On the Effect of High Pressures on the Physical and Chemical Behavior of Solids," *Am. Jour. Sci.*, XXXV, March, 1913.

² *Kristallisieren und Schmelzen*, Barth, Leipzig, 1903.

³ *Op. cit.*, pp. 436, 437, 553-57.

⁴ O. Hecker, "Beobachtungen an Horizontalpendelen," etc., *Veröff. d. Königl. preuss. geodät. Inst.*, 1907.

has not been adequately appreciated. Hecker found that the body tide rises directly under the tide-raising body. This implies that it is the tide of a rigid elastic body. Such a tide obviously has no effective influence in retarding the rotation of the earth by reason of lag; it is effective only in so far as energy is transferred by friction.

We have fallen much short of noting all the significant points in these valuable papers, but we venture to hope that the points cited may be helpful to some readers and may lead to an intimate acquaintance with the papers themselves. These seem to have a common trend, and to prophesy that we may in the near future tread a *terra firma* indeed, and may be permitted in time to build the history of the earth on a solid foundation in a literal as well as figurative sense.

T. C. C.

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